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LXII. *Experiments to prove that the Luminousness of the Sea arises from the Putrefaction of its Animal Substances. By John Canton, M. A. and F. R. S.*

Read Dec. 21, 1769. I SHALL not enter into the consideration of the several opinions of philosophers concerning the luminous appearance of the sea, as not one of them, that I know of, has been well supported; but I shall immediately relate a few experiments, which any person may very easily make, and which, I think, will be allowed to point out the true cause of that appearance, when compared with the descriptions given of it, by those who have accurately observed it.

EXPERIMENT I.

Into a gallon of sea-water, in a pan about 14 inches in diameter, I put a small fresh whiting, June 14, 1768, in the evening; and took notice that neither the whiting, nor the water when agitated, gave any light. A Fahrenheit's thermometer in the cellar, where the pan was placed, stood at 54 degrees. The 15th, at night, that part of the fish which was even with the surface of the water was luminous, but the water itself was dark. I drew the end of a stick
through

through the water, from one side of the pan to the other, and the water appeared luminous behind the stick all the way, but gave light only where it was disturbed. When all the water was stirred, the whole became luminous, and appeared like milk ; giving a considerable degree of light to the sides of the pan that contained it ; and continued to do so for some time after it was at rest. The water was most luminous when the fish had been in it about 28 hours, but would not give any light by being stirred, after it had been in it three days.

EXPERIMENT II.

I put a gallon of fresh water into one pan, and a gallon of sea-water into another, and also into each pan a fresh herring of about three ounces. The next night the whole surface of the sea-water was luminous without being stirred, but much more so when put in motion ; and the upper part of the herring, which lay considerably below the surface of the water was very bright. The fresh water was quite dark, as was also the fish that was in it. There were several very bright luminous spots on different parts of the surface of the sea-water ; and the whole, when viewed by the light of a candle, seemed covered with a greasy scum. The third night, the light of the sea-water while at rest was very little, if at all, less than before ; and when stirred, its light was so great, as to discover the time by a watch ; and the fish in it appeared as a dark substance. After this, its light was evidently decreasing, but was not quite gone before the seventh night. The fresh water, and fish
in

in it, were perfectly dark during the whole time. The thermometer was generally above 60.

EXPERIMENT III.

Into a gallon of fresh water I put common or sea-salt, till I found by an hydrometer it was of the same specific gravity with the sea-water. In another gallon of fresh water I dissolved two pounds of salt: and into each of these waters I put a small fresh herring. The next evening the whole surface of the artificial sea-water was luminous without being stirred, but gave much more light when it was disturbed. It appeared exactly like the real sea-water in the preceding experiment, and its light lasted about the same time, and went off in the same manner*. The other water, which was almost as salt as it could be made, never gave any light. The herring, which was taken out of it the seventh night, and washed from its salt, was found firm and sweet; but the other herring was very soft and putrid; much more so than that which had been kept as long in the fresh water of the last experiment. If a herring, in warm weather, be put into ten gallons of artificial sea-water instead of one, the water will still become luminous, but its light will not be so strong.

N. B. The artificial sea-water may be made without the use of an hydrometer, by the proportion of

* Several river-fish, as the bleak, the dace, the carp, the tench, and the eel, were kept in artificial sea-water to putrefy, without producing any light that I could perceive: but a piece of a carp made the water very luminous, though the outside, or scaly part of it, did not shine at all.

four ounces avoirdupois of salt, to seven pints of water, wine measure.

From the second and third experiments it is evident, that the quantity of salt contained in sea-water hastens putrefaction; as the fish that had been kept in water of that degree of saltiness was found to be much more putrid than that which had been kept the same time in fresh water. This unexpected property of sea-salt was discovered by Sir John Pringle, in the year 1750, and published in the XLVIth volume of the Philosophical Transactions, with many very curious and useful experiments on substances resisting putrefaction; but the greatest quantity of salt there mentioned, is less than what is found in sea-water: it is probable, therefore, that if the sea were less salt, it would be more luminous. And here it may be worth remarking, that, though the greatest summer heat is well known to promote putrefaction, yet 20 degrees more than that of the human blood seem to hinder it: for, putting a very small piece of a luminous fish into a thin glass ball, I found that water of the heat of 118 degrees would destroy its luminousness in less than half a minute; which, on taking it out of the water, it would begin to recover in about ten seconds, but was never after so bright as before.

I shall now only add to these experiments the most circumstantial accounts I can find of the sea's luminous appearance. The Honourable Robert Boyle, in the third volume and 91st page, of Doctor Birch's edition of his works, says, " When I remem-

“ ber how many questions I have asked navigators
 “ about the luminousness of the sea; and how in
 “ some places the sea is wont to shine in the night
 “ as far as the eye can reach; at other times and
 “ places, only when the waves dash against the ves-
 “ sel, or the oars strike and cleave the water; how
 “ some seas shine often, and others have not been ob-
 “ served to shine; how in some places the sea has
 “ been taken notice of, to shine when such and such
 “ winds blow, whereas in other seas the observation
 “ holds not; and in the same tract of sea, within a
 “ narrow compass, one part of the water will be lu-
 “ minous, whilst the other shines not at all: when,
 “ I say, I remember how many of these odd phæ-
 “ nomena, belonging to those great masses of liquor,
 “ I have been told of by very credible eye-witnesses,
 “ I am tempted to suspect, that some cosmical law
 “ or custom of the terrestrial globe, or, at least, of
 “ the planetary vortex, may have a considerable
 “ agency in the production of these effects.”

Father Bourzes has given a still more particular
 account of the luminous appearance of the sea; part
 of which I have extracted from the third edition of
 Jones’s Abridgment of the Philosophical Transactions,
 Vol. V. Part ii. p. 213. “ When the ship ran apace,
 “ we often observed a great light in the wake of the
 “ ship, or the water that is broken and divided by the
 “ ship in its passage. This light was not always
 “ equal; some days it was very little, others not at
 “ all; sometimes brighter, others fainter; some-
 “ times it was very vivid, and at other times nothing
 “ was to be seen. As to its brightness, I could
 “ easily

“ easily read by it, though I was nine or ten feet
 “ above it from the surface of the water ; as I did
 “ particularly on the 12th of June, and the 10th of
 “ July, 1704. But I could read only the title of my
 “ book, which was in large letters. As to the ex-
 “ tent of this light, sometimes all the wake ap-
 “ peared luminous to thirty or forty feet distant
 “ from the ship ; but the light was very faint at any
 “ considerable distance. Some days one might easily
 “ distinguish in the wake such particles as were lu-
 “ minous from those that were not : at other times
 “ there was no difference. The wake seemed then
 “ like a river of milk, and was very pleasant to
 “ look on. At such times as we could distinguish
 “ the bright parts from the others, we observed
 “ that they were not all of the same figure. Some
 “ of them appeared like points of light ; others
 “ almost as large as stars, as they appeared to the
 “ naked eye. We saw some that looked like
 “ globules of a line or two in diameter ; and others
 “ like globes as big as one’s head. It is not
 “ always that this light appears, though the sea
 “ be in great motion ; nor does it always hap-
 “ pen when the ship sails fastest : neither is it
 “ the simple beating of the waves against one an-
 “ other, that produces this brightness, as far as I
 “ could perceive. But I have observed, that the
 “ beating of the waves against the shore has some-
 “ times produced it in great plenty ; and on the
 “ coast of Brazil the shore was one night so very
 “ bright, that it appeared as if it had been all on
 “ fire.

“ The production of this light depends very
 “ much on the quality of the water ; and, if I
 “ am not deceived, generally speaking, I may as-
 “ sert, other circumstances being equal, that the
 “ light is largest when the water is fattest, and fullest
 “ of foam ; for, in the main sea the water is not
 “ every where equally pure ; and sometimes if one
 “ dips linen into the sea, it is clammy when it is
 “ drawn up again. And I have often observed,
 “ that when the wake of the ship was brightest,
 “ the water was more fat and glutinous ; and linen
 “ moistened with it, produced a great deal of light,
 “ if it were stirred or moved briskly. Besides, in
 “ sailing over some places of the sea, we find a
 “ matter or substance of different colours, some-
 “ times red, sometimes yellow. In looking at it,
 “ one would think it was saw-dust : our sailors say
 “ it is the spawn, or seed of whales. What it is,
 “ is not certain ; but when we draw up water, in
 “ passing over these places, it is always viscous and
 “ glutinous. Our mariners also say, that there are
 “ a great many heaps or banks of this spawn in the
 “ north ; and that sometimes in the night they ap-
 “ pear all over of a bright light, without being
 “ put in motion by any vessel or fish passing by
 “ them.

“ But, to confirm farther what I say, videlicet,
 “ that the water, the more glutinous it is, the
 “ more it is disposed to become luminous ; I shall
 “ add one particular which I saw myself. One day
 “ we took in our ship a fish, which some thought
 “ was a boneta. The inside of the mouth of the
 “ fish

“ fish appeared in the night like a burning coal;
 “ so that, without any other light, I could read by
 “ it the same characters that I read by the light
 “ in the wake of the ship. Its mouth being full
 “ of a viscous humour, we rubbed a piece of wood
 “ with it, which immediately became all over lu-
 “ minous ; but, as soon as the moisture was dried
 “ up, the light was extinguished.

“ I leave it to be examined whether all these
 “ particulars can be explained by the system of such
 “ as assert, that the principle of this light consists
 “ in the motion of a subtle matter, or globules,
 “ caused by a violent agitation of different kinds
 “ of salts.”